AEDC CAPABILITY TO PERFORM ENVIRONMENTALLY SAFE DISPOSAL OF SOLID-PROPELLANT ROCKET MOTORS*

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ABSTRACT

The Department of Defense (DoD) has in its storage and operational arsenals an increasing number of large solid-propellant rocket motors (SRM's). There is a need to provide an environmentally acceptable and safe method for the demilitarization, elimination, destruction, or disposal of these SRM's. The Environmental Protection Agency (EPA) has requested those involved to identify methods of disposal, other than Open Burning/Open Detonation (OB/OD), which have less pollution. Arnold Engineering Development Center (AEDC) has been in the altitude, environmental chamber, test mode for over 30 years and has analyzed and treated the environmental issues to the satisfaction of local, state, and federal environmental agencies. AEDC conducted a study of various concepts applicable to the environmentally safe disposal of SRM's based on AEDC altitude rocket testing expertise.

The study looked at the technical feasibility of several proposed concepts for SRM disposal at AEDC. The adaptation of existing facilities for SRM disposal was considered as well as new facilities.

INTRODUCTION

The Environmental Protection Agency (EPA) has advised all the Department of Defense (DOD) facilities that the Resource Conservation and Recovery Act (RCRA) Subpart X was not intended to allow continued operation of Open Burning/Open Detonation (OB/OD) without valid justification.[1] Minimum technology standards are not applicable for the justification, and the facilities must use environmental performance standards. Since disposal of the SRM's is a joint service issue, the Joint Ordnance Commander's Group (JOCG) is exploring alternate disposal techniques which control the release of toxins and contaminants to the environment. AEDC is a member of the JOCG Munitions Demilitarization Subgroup addressing this issue, and has conducted a feasibility study of the possibility of using the test firing modus operandi as an environmentally safe method of disposal. The primary objective of this paper is to describe the capability of AEDC, using test firing techniques, to dispose of SRM's in an environmentally safe manner.

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Technical Feasibility

Constraining Assumptions

When AEDC began to study the concept of Large Solid Rocket Motor (SRM) disposal using test cell technology, the disposal mission was very poorly defined. The disposal need consisted of two main components: those motors retired from service due to age and those retired due to treaty requirements. A low-cost, low-technology, high-throughput disposal facility was the fundamental basis for the concepts explored by this study. Because of the preliminary nature of the disposal mission when this study began, the team started by identifying and evaluating a set of constraining assumptions. Each of these assumptions will be discussed below.

At the time, AEDC identified at least 2,000 motors which were slated for disposal over a ten-year period. These motors were from current inventories of Poseidon (C3), Trident (C4 and D5), Peacekeeper, Minuteman II and III, and Small ICBM (SICBM). The explosive hazard classifications of these motors are Class/Division 1.3 and Class/Division 1.1. The first assumption that was the emphasis of the disposal effort would be on Class/Division 1.1 motors because of the alternative reclamation technology efforts under study for the Class/Division 1.3 HTPB propellants. Further, no motor larger than 83,000 lbm of 1.1 propellant or 100,000 lbm of Class/Division 1.3 propellant would be disposed of. These limits match the current explosive siting limits for Large Rocket Test Facility J-6.[2]

Disposing of Class/Division 1.1 motors presents a greater technical challenge than does the Class/Division 1.3 motors. Since the population of these motors includes potentially defective propellant grains, the risk of detonation is higher than it is for normal test operations. AEDC assumed a technology demonstration effort would reduce the facility risk to the extent that a detonation during motor burn would be an extremely unlikely but potentially catastrophic event.

To keep the disposal operations moving smoothly, and for facility safety, the disposal mission is constrained to whole motors only. Motor fragments, propellant segments, and dissected motors were excluded from this study due to issues associated with logistics and unpredictabilities of results.

The environmental assessment and license acquisition was perceived to be a very unknown obstacle to any disposal operations throughout the solid-propellant rocket community. Since most of the parties active in the manufacturing are located in the western states, we were very interested in the attitude of the regulators for the Tennessee region. After discussions with state representatives, this study assumed that obtaining the necessary permits is possible.

The assumptions necessary for identifying motor storage and logistics requirements presented some conflicting points of view. Inspection and verification requirements associated with START treaty demilitarization efforts were not defined, but could be perceived as conflicting with the security requirements of the testing mission at AEDC. The complete implications of demilitarization treaty requirements remains an open issue, but the siting of a disposal location at AEDC is assumed possible while protecting the testing mission security requirements.

Disposal Concepts

Within the constraining assumptions discussed above, three general disposal concepts were considered: using existing facilities without major modifications; using existing facilities with major modifications; and constructing new facilities at AEDC. Twelve possibilities came out of an industry survey, which were then evaluated against factors such as cost, safety, environmental controls, and impact to the testing mission. This evaluation process resulted in three concepts that provided the most favorable approaches, considering technical, economic, and political factors. The three concepts which were carried through the detailed cost estimating phase of the study were: use of the J-6 facility (Fig. 1); construction of an additional burn chamber to J-6 (Fig. 2); and a standalone steam ejector and scrubber cell (Fig. 3). Please note that J-6 is the only existing AEDC facility that is explosives sited to test 83,000 lbm of Class/Division 1.1 and 100,000 lbm of Class/Division 1.3.

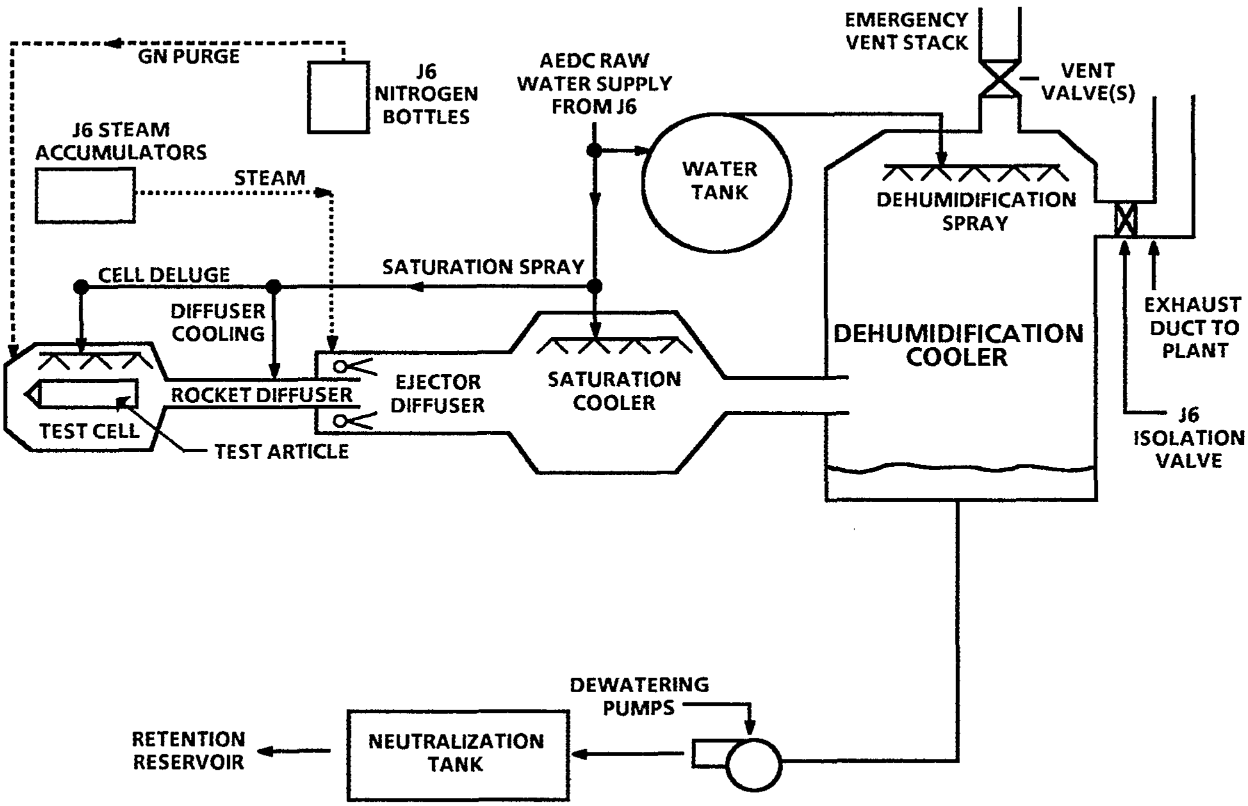

Fig. 1. J-6 operational schematic.

The use of the J-6 facility would minimize construction of new facilities. This concept would use available J-6 plant facility and require some modifications of the test cell itself to remove or protect unneeded high-value equipment such as the thrust measurement system and to improve throughput efficiency. Addition of a water neutralization step in the J-6 dewatering system would be required with the quantities of propellant exhausts being considered here. The use of J-6 would impact

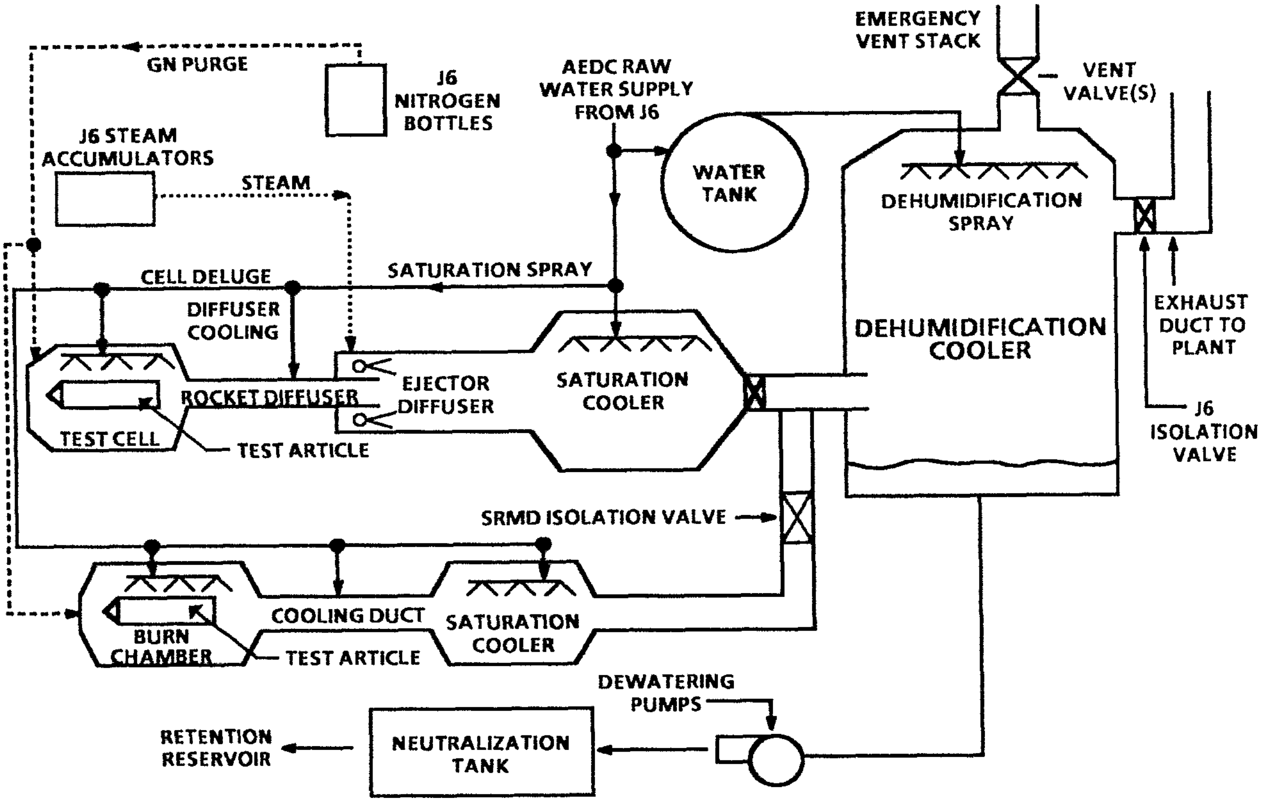

Fig. 2. J-6 leg operational schematic.

scheduled J-6 and Engine Test Facility (ETF) Test and Evaluation (T&E) programs, and also require use of the ETF exhauster facility.

Addition of a separate burn chamber to the J-6 ducting provides several advantages while requiring higher initial costs. First, the burn chamber could be located to provide the necessary distance from the test and evaluation cell to meet intraline distance requirements and reduce impacts to its programs. Second, higher initial construction costs can be offset by designing the disposal cell for maximum production rate efficiency.

A standalone, steam ejector-pumped cell with scrubbing will provide a high level of efficiency and minimize all the interfaces with the J-6 facility. By operating totally separate from the ETF exhauster plant, impacts to the T&E work would be centered only on the coordination of steam, water, and gaseous nitrogen (GN_2) from the J-6 facility. Because of the steam ejector equipment, costs to construct this facility would be the highest of the three approaches.

ENVIRONMENTAL RESTRICTIONS

The large SRM disposal activity at AEDC will be characterized as a "Hazardous Waste Disposal" activity. It will not be classified as an SRM "testing" or "reclamation" activity. The disposal activity will be governed by Subpart X "Miscellaneous

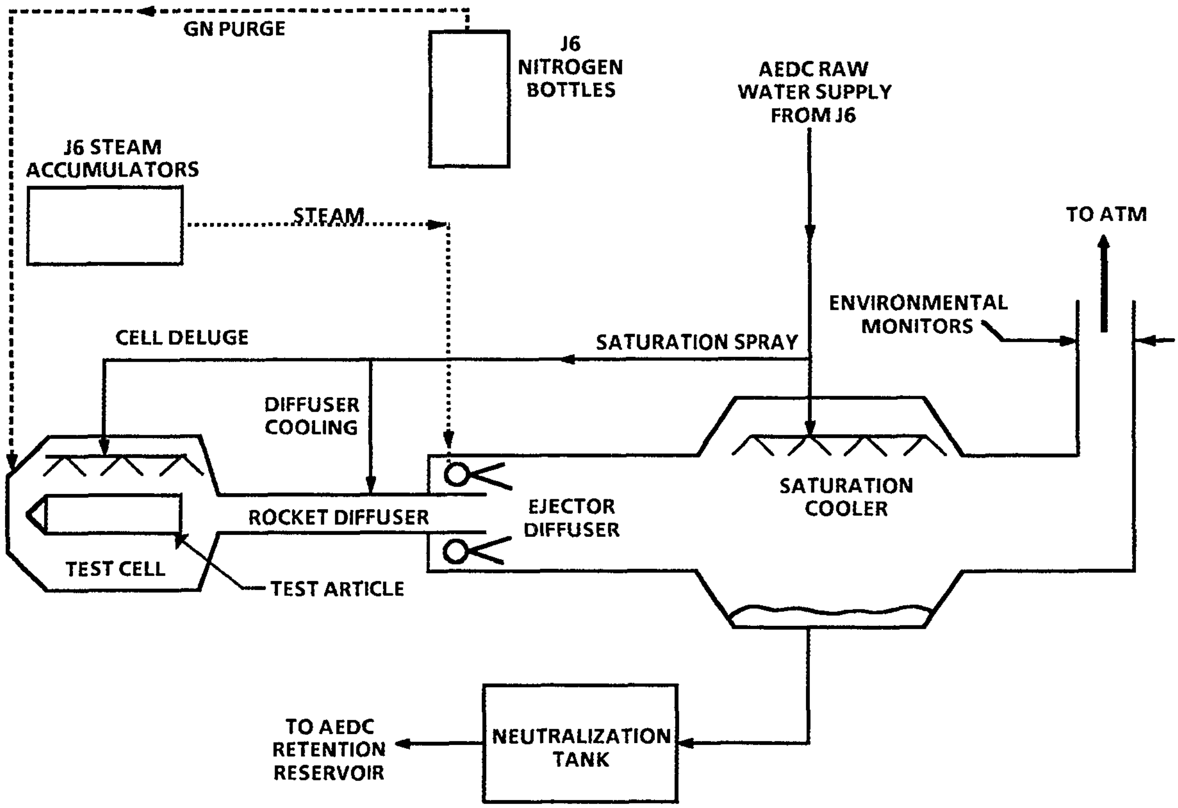

Fig. 3. Ejector to atmosphere operational schematic.

Units" regulations of 40 CFR 264 under the Resources Conservation and Recovery Act. This Subpart X regulation provides for the protection of human health and the environment. It includes, but is not limited to, the prevention of any releases that may have adverse effects on human health or the environment due to: migration of waste constituents in the ground water or subsurface environment; migration of waste constituents in the surface water, or wetlands or on the soil surface; or migration of waste constituents in the air.

A miscellaneous (disposal) unit permit must also contain design and operating requirements, detection and monitoring requirements, and plans for responses to release of hazardous waste or hazardous constituents from the unit to ensure protection as specified in Subpart X.

The SRM's for disposal will include both hazard Class/Division 1.1 and 1.3 propellants which contain various chemical compositions. The technology utilized at AEDC is an environmentally safe and readily available alternative to OB/OD. Information on the composition of various Class/Division 1.1 and 1.3 SRM's that are in the disposal inventory was assessed. Various SRM propellant composition and operational characteristics were input using the NASA SP-273 computer code to predict the SRM's exhaust gas products. A summary of the results is shown in Table 1. The range of both mole fractions and weight fractions is given for the exhaust constituents.

Table 1. Typical SRM Propellant Exhaust Product Composition and Proportion Range

EXHAUST PRODUCTS	MOLE FRACTION RANGE	GAS	LIQUID	SOLID	WEIGHT FRACTION RANGE
Carbon Monoxide (CO)	0.18 — 0.19	X			0.16 — 0.17
Hydrogen Choride (HCl)	0.11 — 0.16	X			0.13 — 0.19
Aluminum Oxide (Al_2O_3)	0.09 — 0.09			X	0.29 — 0.29
Hydrogen (H_2)	0.23 — 0.27	X			0.01 — 0.01
Aluminum Chloride (AlCl)	0.02 — 0.05			X	0.04 — 0.10
Chloride Radical (CL)	0.03 — 0.04	X			0.02 — 0.03
Hydrogen Radical (H)	0.08 — 0.09	X			0.002 — 0.002
Water (H_2O)	0.04 — 0.07		X		0.02 — 0.04
Nitrogen (N_2)	0.07 — 0.07	X			0.06 — 0.06
Hydroxide (OH)	0.006 — 0.010	X			0.003 — 0.005
Hydrogen Cyanide (HCN)	4E-7 — 1E-6	X			3E-1 — 8E-7
Carbon Dioxide (CO_2)	0.004 — 0.007	X			0.006 — 0.009
Nitric Oxide (NO)	3E-4 — 7E-4	X			6E-7 — 2E-4
Nitrogen Dioxide (NO_2)	<5E-7 — <5E-7	X			7E-7 — 7E-7
Aluminum (Al)	0.001 — 0.003			X	8E-4 — 2E-2
Aluminum Nitride (AlN)	<5E-7 — <5E-7			X	6E-7 — 6E-7
Dialuminum Oxide (Al_2O)	3E-4 — 2E-3			X	6E-4 — 4E-3

By-Products To Be Disposed

The SRM exhaust products shown in Table 1 contain all three states of matter (gas, liquid, and solid). The majority of the exhaust products are gases and one of the predominant ones (13%) is hydrogen chloride (HCl), which, when mixed with the spray water, becomes a hydrochloric acid solution. Water is the main liquid product. The predominant solid residue is aluminum oxide, which comprises about 30 percent of the total exhaust product.

An exhaust gas management system consisting of steam ejectors, spray water scrubbers, exhaust ducting, exhausters, and exhaust stacks all combine to condition the exhaust products to a state where it is acceptable to the environment. The functions of the exhaust gas management system are to: cool the exhaust products from approximately 6,000°F to around 100°F; remove the solid aluminum oxide particles and the water soluble products such as hydrogen chloride; compress the exhaust gas before it is discharged to the atmosphere; and abate the fire/explosion hazard in the ducting because of the hydrogen and carbon monoxide in the exhaust products. The scrubbing of the exhaust gas by direct water sprays, and its discharge

to atmosphere are the main ingredients which contribute to an environmentally safe disposal system.

Environmental Impact Analysis

The preparation of an environmental assessment and a Finding of No Significant Impact (FONSI) will help fulfill the requirements of the National Environmental Policy Act (NEPA). If the environmental assessment reveals that the impact will be significant, then it will be necessary to prepare an Environmental Impact Statement (EIS) instead of a FONSI. The EIS, a much more detailed analysis, will take almost twice as long to complete as the FONSI at considerably more cost.

Environmental Permits

Members of the Tennessee Department of Environment and Conservation (TDEC) were briefed on the environmental aspects of the controlled disposal concept. The preliminary response from the TDEC concerning the possibility of siting a large rocket disposal facility at AEDC was very favorable. A letter was received from the TDEC in October 1991 which stated that "to date, no environmental issue has been recognized that would threaten the project." The Subpart X permit can be issued as an amendment to AEDC's existing Part-B RCRA permit for storage. TDEC also stated that for converting a test unit to a nonhazardous waste unit, full closure requirements will apply. AEDC must establish pre-disposal operation contamination levels, i. e., existing levels resulting from testing operations, to be used as a baseline to compare against closure cleanup standards.

Additionally, both air and water discharge permits will be required for the disposal operations. TDEC stated in their letter that a PSD (prevention of signification deterioration) review will be required prior to issuance of an air permit for the disposal operation. The water discharge permit for the scrubber water will be meshed into the current National Pollutant Discharge Elimination System (NPDES) permit. AEDC's construction landfill permit will have to be modified to identify Al_2O_3 sludge as a waste for disposal.

Source Monitoring

The air permit for the disposal operation will likely require source monitoring for particular exhaust products. The permit-required monitoring would include specifications on sampling, measurements, and sensitivity of analysis. TDEC feels that the high-flow, short-duration emission from a rocket motor firing is not suitable for the application of electro-optical monitoring equipment which is normally set up for continuous monitoring of long-duration emissions. Therefore, sampling and laboratory analysis of exhaust products would be a preferred method of emission monitoring.

CONCLUSIONS

The use of AEDC testing expertise and existing facilities is a sound, technically feasible solution for the disposal operations in an environmentally acceptable manner. The residual material in the exhaust gas can be handled and returned to the base ecological system in an occupationally and environmentally safe manner. The

State TDEC's preliminary response to the proposed concepts of disposal has been very encouraging.

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2. Mohyuddin, Z., Cyran, F. B., and Le, T. V., "Potential Applications of Rocket Test Exhaust Scrubber Techniques to Solid Rocket Demilitarization At Arnold Engineering Development Center," Paper presented at JANNAF Safety and Environmental Subcommittee Meeting, August 1992, Monterey, CA.